PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) **International Patent Classification:** **G02F 1/1337, G02F 1/1333**	**A1**	(11) **International Publication Number:**	**WO 00/08521**
		(43) **International Publication Date:**	17 February 2000 (17.02.2000)

(21) **International Application Number:** PCT/BY98/00008

(22) **International Filing Date:** 25 September 1998 (25.09.1998)

(30) **Priority Data:**
19980744 06 August 1998 (06.08.1998) BY

(60) **Parent Application or Grant**
KONOVALOV, Victor A. [/]; (). MURAVSKY, Anatoly A. [/]; (). YAKOVENKO, Sergey E. [/]; (). TIMOFEEV, Sergey N. [/]; (). KONOVALOV, Victor A. [/]; (). MURAVSKY, Anatoly A. [/]; (). YAKOVENKO, Sergey E. [/]; (). TIMOFEEV, Sergey N. [/]; (). GORYACHKO, Mariam Sh. ; ().

Published

(54) **Title: LIQUID-CRISTAL DISPLAY AND THE METHOD OF ITS FABRICATION**
(54) **Titre: AFFICHEURS A CRISTAUX LIQUIDES ET SON PROCEDE DE FABRICATION**

(57) Abstract

The present invention is aimed to make displays with wide viewing angle possessing higher brightness in transmission mode and to develop more simple method for making such displays. This target is achieved by making in display with multiple pixels deflecting elements (5, 6) of dielectric material and depositing them over the electric conductive coating at least on one of the substrates (1, 2) the space between which is occupied by liquid crystal. Dielectric deflecting elements (5, 6) may be displaced along the perimeter of the pixel as well as across its area. After applying electric voltage to the electrodes (3) at the opposite substrates (1, 2) at the interface LC-dielectric deflecting element distortions of the electric field arise with the component of electric field parallel to the substrates.

(57) Abrégé

L'invention vise à obtenir des afficheurs à large angle de vision ayant une luminosité plus élevée en mode de transmission et à mettre au point un procédé plus simple pour fabriquer ces afficheurs. Pour ce faire, il faut élaborer un afficheur avec de multiples éléments de déviation de pixels (5, 6) en matériau diélectrique et les déposer sur un revêtement conducteur électrique au moins sur un des substrats (1, 2), l'espace intermédiaire étant occupé par des cristaux liquides. Les éléments de déviation diélectriques (5, 6) peuvent être déplacés le long du périmètre du pixel et autour de sa zone. Une fois les électrodes (3) alimentées en tension électrique au niveau des substrats opposés (1, 2) au niveau des éléments de déviation diélectrique CL d'interface, des distorsions du champ électrique apparaissent avec la composante du champ électrique parallèle aux substrats.

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G02F 1/1337, 1/1333

A1

(11) International Publication Number: **WO 00/08521**

(43) International Publication Date: 17 February 2000 (17.02.00)

(21) International Application Number: PCT/BY98/00008

(22) International Filing Date: 25 September 1998 (25.09.98)

(30) Priority Data:
19980744 6 August 1998 (06.08.98) BY

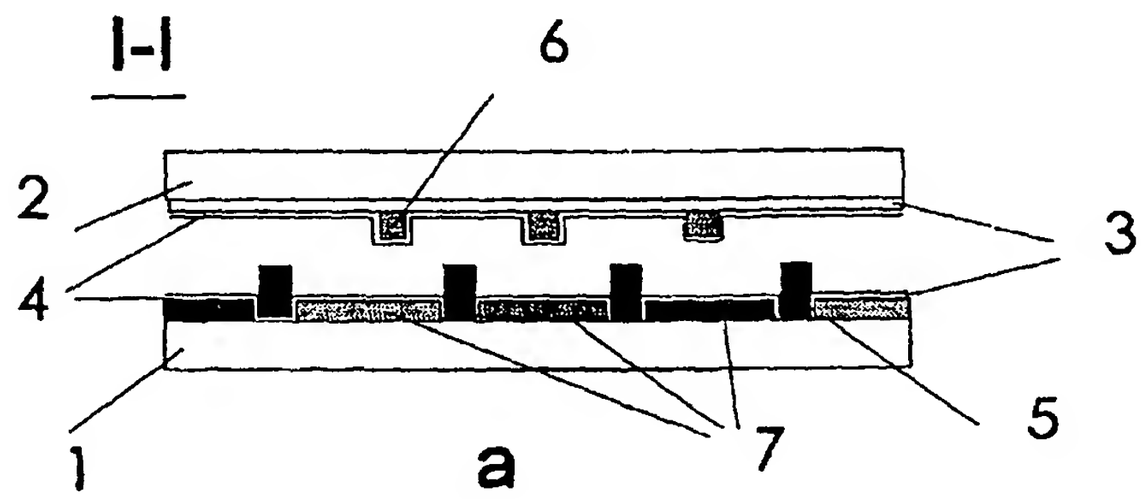
(71)(72) Applicants and Inventors: KONOVALOV, Victor A. [BY/BY]; Yakubova str. 6–4–26, Minsk, 220095 (BY). MURAVSKY, Anatoly A. [BY/BY]; Plekhanova str. 53–88, Minsk, 220085 (BY). YAKOVENKO, Sergey E. [BY/BY]; per. Kaliningradsky, 13–95, Minsk, 220012 (BY). TIMOFEEV, Sergey N. [BY/BY]; Kakhovskaya str. 34–9, Minsk, 220068 (BY).

(74) Agent: GORYACHKO, Mariam Sh.; P.O. Box 133, Minsk, 220012 (BY).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: LIQUID–CRISTAL DISPLAY AND THE METHOD OF ITS FABRICATION



(57) Abstract

The present invention is aimed to make displays with wide viewing angle possessing higher brightness in transmission mode and to develop more simple method for making such displays. This target is achieved by making in display with multiple pixels deflecting elements (5, 6) of dielectric material and depositing them over the electric conductive coating at least on one of the substrates (1, 2) the space between which is occupied by liquid crystal. Dielectric deflecting elements (5, 6) may be displaced along the perimeter of the pixel as well as across its area. After applying electric voltage to the electrodes (3) at the opposite substrates (1, 2) at the interface LC–dielectric deflecting element distortions of the electric field arise with the component of electric field parallel to the substrates.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

Description

LIQUID–CRISTAL DISPLAY AND THE METHOD OF ITS FABRICATION

Field of the Invention

Invention is related to the field of electronics and can be used for making information displays, in particular, liquid crystal (LC) indicators, screens, panels etc.

Prior Art

The drawback of the majority of liquid crystal displays is a strong dependence of their transmission on the angle of light incidence [S.T.Wu, C.S.Wu, SID Digest 27, 763 (1996)-1] and, as a result, decrease of contrast and even inversion of transmission levels at some observation angles. For improving these characteristics of displays in many cases a set of retardation plates is used [N.Yamagishi, H.Watanabe, K.Yokoyama, 'Japan Display 89', 316 (1989)-2], which increases the cost of the device and does not resolve the problem of color inversion.

The most promising from this point of view are multi-domain LC displays, in which a single pixel contains areas with various orientations of the liquid crystal in the plane of substrates [M.Schadt, Proc.SID'97, 24.1 (1997)-3].

There is an information display [K.-H.Kim,S.-B.Park,J.-U.Shim,J.-H.Souk,J.Chen, SID 98 DIGEST, 1085 (1998)-4], which consists of two plane and parallel substrates with electrodes deposited at least on one of them, the said substrates are overlaid with the electrodes facing each other. The space between the substrates is filled with a homeotropically aligned liquid crystal mixture possessing positive anisotropy. From the outside the substrates are surrounded by two crossed polaroids. In the off state this display does not transmit the light. After electric voltage of the opposite polarity is applied to the neighboring electrodes at one of the substrates, a parabolic electric field is created between the said electrodes, which reorients the liquid crystal parallel to it. In this way it is possible to orient LC molecules between the

electrodes in two different directions (the so-called two-domain structure) and as the result, the viewing angle of such display is improved considerably. To maximize the brightness polaroids are oriented at 45° to the electrodes. Nevertheless, low brightness is the drawback of this display, as well as of other displays based on director re-switching in the plane of the substrates [M.Ohta et al, Asia Display'95, 707 (1995)-5]. Another drawback is that it is impossible to have more than two domains in a pixel.

There is display [S.-C. A.Lien, R.A.John, Patent USA, US5,309,264-6], [S.-C. A.Lien, R.A.John, et al, SID 98 DIGEST, 1123 (1998)-7], in which two principles are used to have domain structure: fringe field, which arises at the edge of the electrode after applying electric field, and ridge field at the opposite slopes of the protrusions formed lithographically at the opposite substrates with color filters. Protrusions act as elements which incline LC director from the normal to the substrate. The space between the substrates is filled with homeotropically aligned liquid crystal possessing negative dielectric anisotropy. Liquid crystal molecules are aligned perpendicularly to the substrates surface and in the off state this display does not transmit the light (crossed polaroids) and only on the slopes of protrusions the molecules deviate from the normal to the angle which equals the angle between the slope of the protrusion and the substrate. At the slopes the molecules are pre-tilted in different directions, but pre-tilt is not high and therefore it does not perturb optical parameters of display in the off state. Within the pixel protrusions are oriented so that the pre-tilt direction coincides with the direction of the fringe field which arises at the long edge of the pixel (the pixel has elongated rectangular shape). In such display co-action of the fringe electric field and protrusions result in reorienting LC molecules within the pixel in different directions relative to the long axes of the protrusions. The drawback of such device is that although it is possible to have four domains within a pixel (this number of domains is optimal for equalizing optical characteristics in different directions), but in a real display these domains have different area and it is difficult to equalize optical characteristics completely. Besides this, the fringe field which arises around the pixel after applying electric voltage is distorted by connecting buses and this results in non-uniform switching of various domains within a pixel.

The closest to the proposed devices and method is technical reference [A.Takeda et al, SID 98 DIGEST, 1077 (1998)-8]. This display consists of two substrates with the pattern of electrodes

deposited on them, on the said electrodes protrusions are deposited photolithographically with the slopes in different directions. These protrusions like similar elements in [7] tilt the LC director from the normal of the substrate. The space between the substrates if filled with homeotropically aligned liquid crystal possessing negative dielectric anisotropy. In the off state the LC molecules are orthogonal to the substrates except those in the areas where the protrusions are displaced. At the slopes of the protrusions the molecules are pre-tilted to the angle, which equals the angle between the slope and the substrate. This pre-tilt is not high and does not perturb optical characteristics of the display in the off state and in crossed polaroids display does not transmit the light. When the voltage is applied to the electrodes at the opposite substrates this pre-tilt is sufficient to initiate molecular reorientation in different directions within the pixel area. This leads to appearing domains and makes viewing angle more uniform. The drawback of this display is low brightness (30% of conventional single-domain display) because of two factors: protrusions occupy more than 30% of the display area and to realize four domains very specific pattern of the protrusions is required, which leads to additional losses of light. Besides this to make this display two additional photolithographies are required.

Summary of the Invention

Present invention is aimed to make displays with wide viewing angle possessing higher brightness in transmission mode and to develop more simple method for making such displays.

This target is achieved by making in display with multiple pixels deflecting elements of dielectric material and depositing them over the electric conductive coating at least on one of the substrates the space between which is occupied by liquid crystal. Dielectric elements can have profile as from the liquid crystal side, so from the side of the substrate. They can be deposited on both, as well as only on one substrate. Dielectric deflecting elements may be displaced along the perimeter of the pixel as well as across its area. After applying electric voltage to the electrodes at the opposite substrates at the interface LC-dielectric deflecting element distortions of the electric field appear with the component of electric field parallel to the substrates. Direction of this in-plane component is determined by the configuration of the dielectric deflecting elements. The value of this component is sufficient to reorient liquid crystal in different directions and hence to generate different domains within the pixel area and to make optical properties of display independent of the viewing angle. Unlike in the known display [8],

dielectric elements take not more than 5-10% of the pixel area and proposed display has higher brightness. At the same time configuration of the dielectric elements is capable of obtaining two- as well as four domain displays for any real pixel shape.

Brief Description of the Drawings

Figs.1-2 show the cross-section (a) and the top view (b) of the proposed display, fabricated according to the proposed method with various displacement of the dielectric deflecting elements.

Fig.3 shows the cross-section (a) and the top view (b) of the proposed display, fabricated according to the proposed method, in the said display the dielectric deflecting elements are displaced at the color filters substrate and play the role of the black mask.

Fig.4 shows the top view of the displays fabricated according to the proposed method with various displacement of the dielectric deflecting elements.

Figs.5-8 show the cross-section (a) and the top view (b) of the proposed display, fabricated according to the proposed method with various displacement of the dielectric deflecting elements in the cases when these elements have profiled thickness at the side of the substrate.

Fig.9 shows the cross-section (a) and the top view (b) of the proposed two-domain display, fabricated according to the proposed method with planar alignment of the liquid crystal.

Detailed Description of the Preferable Embodiments

The proposed displays are fabricated as following.

On one or both substrates with aligning layer deposited on them dielectric deflecting elements are patterned on the top of the last electric conductive layer. Resistivity of the deflecting elements should not be substantially lower than that of the liquid crystal material, the last is usually higher than 10^8 Ohm/cm.

Deflecting elements are usually formed photolithographically. Most often they have shape of solid or dashed lines with the intervals between the dashes 5-30 μm, the line-width 2-3 μm and larger and the height (or depth) from 0.1 μm up to the LC thickness. The cross section of the deflecting dielectric elements may have the shape of any geometric figure, such as triangle, turned with one side to the substrate, trapezium, rectangle, semicircle e.t.c. Deflecting dielectric elements are patterned to have the form of lines of any type surrounding the pixel. If pixel has elongated shape, it may be subdivided by deflecting elements into squares, or rectangles with the shape close to squares. Deflecting elements may be displaced in the gap between the electrodes and cover part of the electrode with the width comparable to the height of the element in order to avoid the influence of the fringe field on the LC orientation. The area between the deflecting elements may be filled with supplementary coatings (variants with the deflecting dielectric elements profiled from the side of the substrate). Supplementary coatings may play the role of planarizing film, or color filters matrix, or various conductive layers. This may be the areas of the substrate, between which the wells are made, which are filled with the deflecting dielectric elements.

At the second substrate deflecting elements are also deposited to have a shape of squares, or rectangles with the shape close to squares with the same dimensions as on the first substrate, or with different dimensions, or having shape of solid, or dashed lines of various form.

In the case when matrix of color filters is formed at the second substrate, deflecting dielectric elements usually align with the black matrix, or replace them by dielectric black matrix. In the latter case one technological operation is reduced.

Deflecting dielectric elements on different substrates can be made of different materials. For example, when on the color filter substrate deflecting dielectric elements are replaced by the black matrix, on the second substrate they are made from as transparent material as possible to reduce the losses of light. The height of the deflecting dielectric elements may vary across the substrate and may be different on different substrates. The first case can be useful to make displays with variable viewing angle across the display area.

At the next stage aligning layer for homeotropic or planar alignment is deposited at the substrates.

To control the gap between the substrates in the case when deflecting elements are deposited only on one substrate conventional spacers, such as spheres, or fibers, or particles of definite dimensions made of inorganic as well as organic materials are used. In the case when deflecting elements are deposited on the electrodes on both substrates and have profile from the side turned to the liquid crystal, additional spacers are not necessary because deflecting dielectric elements play the role of spacers. Simultaneously, the display becomes more rugged and the LC layer thickness can be easily varied during fabrication process.

At the next stage of fabricating display with deflecting dielectric elements deposited on one substrate this substrate is overlaid with another one, containing pattern of electrodes, aligning layer and conventional spacers with the said electrodes faced to each other on both substrates and is sealed along the perimeter.

In the case the display has deflecting dielectric elements on both substrates with the profile from the liquid crystal side to obtain equally good viewing characteristics for all observation angles these deflecting elements are aligned so that the crossings of the lines on one substrate be as close as possible to the centers of the squares formed by deflecting dielectric elements on the second substrate. After this display is sealed.

If at least on one of the substrates deflecting dielectric elements are profiles from the side of the substrate, then the substrates are aligned similarly to the previous case, but conventional spacers are used to control the gap between the substrates.

As a rule, liquid crystal domains are formed of equal size to make viewing characteristics independent of angle. Nevertheless, they can have different size if display should have specific viewing characteristics.

The space between the substrates is filled with liquid crystal.

This liquid crystal can possess either positive or negative dielectric anisotropy. Consequently, the said liquid crystal may have either planar of homeotropic alignment. Planar aligning material is rubbed. The angle between the rubbing direction and the deflecting dielectric elements may

be taken in the range 0° - 180°. Both non-chiral and chiral liquid crystal materials are appropriate. In the case it is chiral and has planar alignment it may be twisted to the angle from 0° to 360°. If it has homeotropic alignment, its twist angle should be chosen so that $d/p < 0.5$ (here d - LC layer thickness, p - its spontaneous helix pitch).

In the proposed displays liquid crystal doped with a dichroic dye can be used and then such display may operate without polaroids and information is displayed due to light absorption by the dye molecules. The dichroic ratio of the dye can be larger or smaller than 1 and liquid crystal may be chiral or non-chiral.

Proposed displays can operate in reflective mode. In such a case one of the substrates and the electrode deposited on it are made non-transparent (reflective). The image is obtained with one polaroid.

Fig.1 shows the cross-section (a) and the top view (b) of the proposed display, fabricated according to the proposed method. On two plane glass substrates 1 and 2 0.5-2 mm thick and with linear dimensions on the range of 1 cm to several decimeters transparent electrodes from conductive coating 3 having thickness 70-150 nm and surface resistivity10-2000 Ohm/□ are deposited in vacuum from the oxide of the indium-tin alloy. The desirable electrode pattern is made photolithographically. On one substrate deflecting dielectric elements 5 are formed from photoresistive dielectric material, for example AR P-310, which have the shape of crossing lines with the pitch 100 μm, width 5-7 μm and height 2.5-3 μm. Both substrates 1, 2 are covered with homeotropic aligning layer 4, for example AL-655 (JSR), 20-100 nm thick. Conventional spacers, like plastic spheres 3-6 μm in diameter, are deposited on one of the substrates 1, 2. The substrates 1, 2 are overlaid with the aligning layers 4 faced to each other and fixed together with the sealing material having epoxy base, for example UHU plus endfest 300. The space between the substrates 1, 2 is filled with liquid crystal possessing negative dielectric anisotropy, such as MLC-6608. So made display transmits 45-50% of light in the on state in crossed polaroids (for 100% we take the light transmitted by display in the off state between the parallel polaroids).

Fig.2 shows the cross-section (a) and the top view (b) of the proposed display, fabricated according to the proposed method. On two plane glass substrates 1 and 2 on the top of the conductive layer 3 deflecting dielectric elements (5), (6) are deposited in the form of crossing lines with the width 5-6 μm, their height is 2.0-2.5 μm and the pitch - 100 μm. The substrates 1, 2 are aligned so, that line crossings on one substrate are close to the centers of the squares formed by the lines on the second substrate. The crossings of the lines on different substrates are used as spacers. Single pixel abcd is surrounded by thicker vertical lines and two horizontal lines placed at the bottom substrate 1. So made display transmits 75-80% of light in the on state in crossed polaroids.

Fig.3 shows the cross-section (a) and the top view (b) of the proposed display, fabricated according to the proposed method, in which deflecting elements 5 at the color filters substrate are made of non-transparent dielectric material and have the form of lines 5-15 μm thick with the height 2-2.5 μm above the color filters surface. Simultaneously these deflecting elements play the role of the black matrix. Pixel abcd is surrounded by peripheral vertical lines and two horizontal lines placed at the bottom substrate 1. In other aspects the display is made similarly to that one described in fig.2. This display has brightness 60-80% in the on state.

Fig.4 shows the top view of the proposed displays fabricated according to the proposed method with various displacements of the deflecting dielectric elements 1 and 2 on the bottom and the top substrates respectively. Single pixel is displayed. In other aspects the display is made similarly to that one described in fig.2. This display has brightness 75-80% in the on state.

Fig.5 shows the cross-section (a) and the top view (b) of the proposed display, fabricated according to the proposed method. On the bottom 1 and top 2 substrates containing the electrodes pattern 3 deflecting dielectric elements 5 and 6 are deposited. On the bottom substrate 1 the area between the dielectric deflecting elements is filled with a supplementary layer 7 possessing dielectric constant different from that of the deflecting elements (dielectric deflecting elements are profiled from the side of the substrate). On the top of all patterns on both substrates 1, 2 homeotropically aligning layer 4 is deposited. Conventional spacers, like plastic spheres 3-6 μm in diameter, are used. Pixel abcd is surrounded by thicker vertical lines

and two horizontal lines placed at the bottom substrate 1. In other aspects the display is made similarly to that one described in fig.1. This display has brightness 75-80% in the on state.

Fig.6 shows the cross-section (a) and the top view (b) of the proposed display, fabricated according to the proposed method. On the bottom 1 and top 2 substrates containing the electrodes pattern 3 deflecting dielectric elements 5 and 6 are deposited. On the bottom substrate 1 the area between the dielectric deflecting elements is filled with a supplementary layer 7 possessing dielectric constant different from that of the deflecting elements (dielectric deflecting elements are profiled from the side of the substrate). On the top of the supplementary layer 7 conductive coating 3 is deposited. On the top of all patterns on both substrates 1, 2 homeotropically aligning layer 4 is deposited. Conventional spacers are used. Pixel abcd is surrounded by thicker vertical lines and two horizontal lines placed at the bottom substrate 1. In other aspects the display is made similarly to that one described in fig.1. This display has brightness 75-80% in the on state.

Fig.7 shows the cross-section (a) and the top view (b) of the proposed display, fabricated according to the proposed method. On the bottom 1 and top 2 substrates containing the electrodes pattern deflecting dielectric elements 5 and 6 are deposited. On the bottom substrate 1 the area between the dielectric deflecting elements 5 is filled with a supplementary layer 7 possessing dielectric constant different from that of the deflecting elements (dielectric deflecting elements are profiled from the side of the substrate). On the top of the supplementary layer 7 conductive coating 3 is deposited. On the top of conductive coating 3 the film made of material of the deflecting dielectric element is displaced and covered with the aligning film 4. Conventional spacers are used. Pixel abcd is surrounded by thicker vertical lines and two horizontal lines placed at the bottom substrate 1. In other aspects the display is made similarly to that one described in fig.1. This display has brightness 75-80% in the on state.

Fig.8 shows the cross-section (a) and the top view (b) of the proposed display, fabricated according to the proposed method. On the bottom 1 and top 2 substrates containing the electrodes pattern deflecting dielectric elements 5 and 6 are deposited. On the bottom substrate 1 the area between the dielectric deflecting elements 5 is filled with a supplementary layer 7 which is made of the same material as the substrate (in a real process the grooves are made in the substrate in advance and after depositing electric conductive coating the grooves are filled

with the dielectric deflecting elements 5). On the top of the supplementary layer 7 conductive coating 3 is deposited. On the top of conductive coating 3 the aligning film 4 is displaced. Conventional spacers are used. Pixel abcd is surrounded by peripheral vertical lines and two horizontal lines placed at the bottom substrate 1. In other aspects the display is made similarly to that one described in fig.1. This display has brightness 75-80% in the on state.

Fig.9 shows the cross-section (a) and the top view (b) of the proposed display, fabricated according to the proposed method. On two plane glass substrates 1, 2 on the top of the conductive layer 3 deflecting dielectric elements 5, 6 are deposited. On one substrate, let us tell substrate 1, deflecting elements 5 have the form of crossing dielectric lines and on another substrate, for example 2, they look like dielectric lines. Lines on the both substrates 1, 2 have the width 5-6 μm, their height is 2.0-2.5 μm and the pitch - 100 μm. The substrates 1, 2 are aligned so, that the lines on substrate 2 cross the sides of the rectangles formed by the lines on the substrate 1 close to their centers. The crossings of the lines on substrate 1 with the lines on the substrate 2 are used as spacers. Planar aligning layer 4, for example AL-3046 (JSR), is deposited on both substrates 1, 2. The substrates 1, 2 are rubbed parallel to each other and perpendicular to the lines on the substrate 2. The space between the substrates 1, 2 if filled with a nematic liquid crystal ZLI-3497-000 possessing positive dielectric anisotropy. Single pixel abcd is surrounded by thicker vertical lines and two horizontal lines placed at the bottom substrate 1. So made display transmits 85-90% of light in the off state in crossed polaroids.

The proposed display with homeotropic alignment of the liquid crystal possessing negative dielectric anisotropy operates as following.

In the state without electric field LC molecules are aligned orthogonal to the substrates 1, 2 in the whole area except the slopes of the deflecting dielectric elements 5, 6, in the case their profile is from the liquid crystal side. In difference to [7,8], in the proposed display the slopes of the deflecting elements are either very steep (the angle with the substrate normally is bigger than 30-40°), or they are absent at all, in the case they are profiled from the substrate side. So distortions of the liquid crystal alignment either have limited size, or absent at all and do not perturb optical parameters of the display. Therefore in the off state this display does not transmit light in the crossed polaroids.

After applying electric field liquid crystal reorients not uniformly across the pixel area, but according to the direction of the parallel to the substrates component of the electric field which appears at the LC - dielectric interface. This way domains with different (including opposite) orientation of the liquid crystal appear within the pixel area. Under various observation angles different domains have different transmittance and transmittance of the pixel as a whole equals some averaged value. Due to this, inversion of the transmission levels of LC display under various observation angles is suppressed, similarly to the effect observed in [7,8]. To increase the viewing angle (to increase the contrast under oblique observation angles) phase retarders [2] may be used in the proposed display.

Display with LC possessing positive dielectric anisotropy and aligned parallel to the substrates operates in a similar way. The difference is that in the off state this display transmits light in crossed polaroids. After applying electric field LC reorients in different directions depending on the direction of the in-plane with the substrates component of the distorted electric field, which is created at the LC-dielectric interface. As the result, viewing characteristics become similar for different observation angles. In the on state display becomes non-transparent.

Summarizing the analysis of the proposed display and the method for its fabrication one can tell, that using conventional technology for making LC displays, in which only one technological photolithographic stage is added for making deflecting dielectric elements, it is easy to obtain display with wide viewing angle. The number of domains, their displacements, as well as proportion of their areas can be easily varied by varying photolithographically made pattern. Besides this, in transmission mode the losses of light are in the range of 10-20% in comparison with conventional single-domain displays, which are not essential for the desk-top displays.

Claims

CLAIMS

1. Liquid crystal display with plurality of pixels comprised of two plane substrates (1), (2) with electric conductive layers deposited on the faced to each other sides of the substrates (1), (2), covered with aligning layers (4) and with liquid crystal filling the space between the substrates (1), (2), having deflecting elements (5), (6) and, if required, black matrix, characterized in that

at least on one substrate deflecting elements (5), (6) are dielectric and are displaced over electric conductive layers along the perimeter of each pixel.

2. Display according to claim 1, characterized in that, deflecting dielectric elements (5), (6) are made of material with the resistivity equal, or exceeding the resistivity of the liquid crystal.

3. Display according to claims 1-2, characterized in that, deflecting dielectric elements (5), (6) are additionally displaced within the area of each pixel.

4. Display according to claims 1 or 2, characterized in that, the said black matrix is made of deflecting dielectric elements (5), (6).

5. Display according to claims 1-4, characterized in that, deflecting dielectric elements (5), (6) have the height in the interval 0.1-1 value of the liquid crystal thickness.

6. Display according to claim 1, characterized in that, deflecting dielectric elements (5), (6) are displaced on both substrates (1), (2) over the electric conductive layers.

7. Display according to claim 6, characterized in that, deflecting dielectric elements (5), (6) which are displaced over the electric conductive layers are made of different materials.

8. Display according to claims 1-7, characterized in that, deflecting dielectric elements (5),(6) have varying height.

9. Liquid crystal display with plurality of pixels comprised of two plane substrates (1), (2) with electric conductive layers deposited on the faced to each other sides of the substrates (1), (2), covered with aligning layers (4) and with liquid crystal filling the space between the substrates (1), (2), having deflecting elements (5), (6) and, if required, black matrix, characterized in that

at least on one substrate deflecting elements are dielectric and placed over the electric conductive layer and the area between them is filled with a supplementary coating (7).

10. Display according to claim 9, characterized in that, on the top of the supplementary coating (7) additional conductive layer is deposited.

11. Display according to claims 9 or 10, characterized in that, over the said dielectric deflecting elements (5), (6) and supplementary coating (7) additional layer is formed made of the material of the said deflecting dielectric elements (5), (6).

12. Display according to claim 9, characterized in that, the said dielectric deflecting elements (5), (6) are made of material with the resistivity equal or exceeding that of the said liquid crystal.

13. Display according to claims 9-12, characterized in that, deflecting dielectric elements (5), (6) are additionally displaced within the area of each pixel.

14. Display according to claims 9 or 13, characterized in that, the said black matrix is made of deflecting dielectric elements (5), (6).

15. Display according to claims 9-14, characterized in that, deflecting dielectric elements (5), (6) have the height exceeding 0.1 of the liquid crystal thickness.

16. Display according to claim 9, characterized in that, deflecting dielectric elements (5), (6) are displaced on both substrates (1), (2) over the electric conductive layers.

17. Display according to claim 16, characterized in that, deflecting dielectric elements (5), (6) which are displaced over the electric conductive layers are made of different materials.

18. Display according to claims 9-16, characterized in that, deflecting dielectric elements (5), (6) have varying height.

19. Display according to claim 9, characterized in that, the supplementary coating (7) is made of the same material as the substrate.

20. Display according to claim 19, characterized in that, on the top of the supplementary coating (7), which is made of the same material as the substrate, electric conductive layer is deposited.

21. The method for making liquid crystal display with plurality of pixels comprised of depositing electric conductive and aligning layers on the faced to each other sides of two plane substrates, of subsequent filling liquid crystal in the space between the substrates, of forming deflecting elements and, if required, color filters and black matrix,
characterized in that
at least on one substrate deflecting elements are made dielectric and are displaced over the electric conductive layer.

22. The method according to claim 21, characterized in that, deflecting dielectric elements are made of material with the resistivity equal to or exceeding that of the liquid crystal.

23. The method according to claims 21 or 22, characterized in that, deflecting dielectric elements are formed on both substrates.

24. The method according to claim 23, characterized in that, deflecting dielectric elements are formed of different materials

25. The method according to claims 21-24, characterized in that, the area between the deflecting dielectric elements is filled with supplementary coating.

26. The method according to claim 25, characterized in that, on the top of the supplementary coating additional electric conductive layer is deposited.

27. The method according to claims 24 or 25, characterized in that, on the top of the supplementary coating additional layer made of the material of the deflecting dielectric elements is deposited.

28. The method according to claim 21, characterized in that, the supplementary coating is made of the same material as the substrate.

29. The method according to claim 25, characterized in that, on the top of the supplementary coating electric conductive layer is deposited.

30. The method according to claims 21-23, characterized in that, the black matrix is made of the material of the deflecting dielectric elements.

31. The method according to claim 21, characterized in that, deflecting dielectric elements are formed with the height exceeding 0.1 of the liquid crystal thickness.

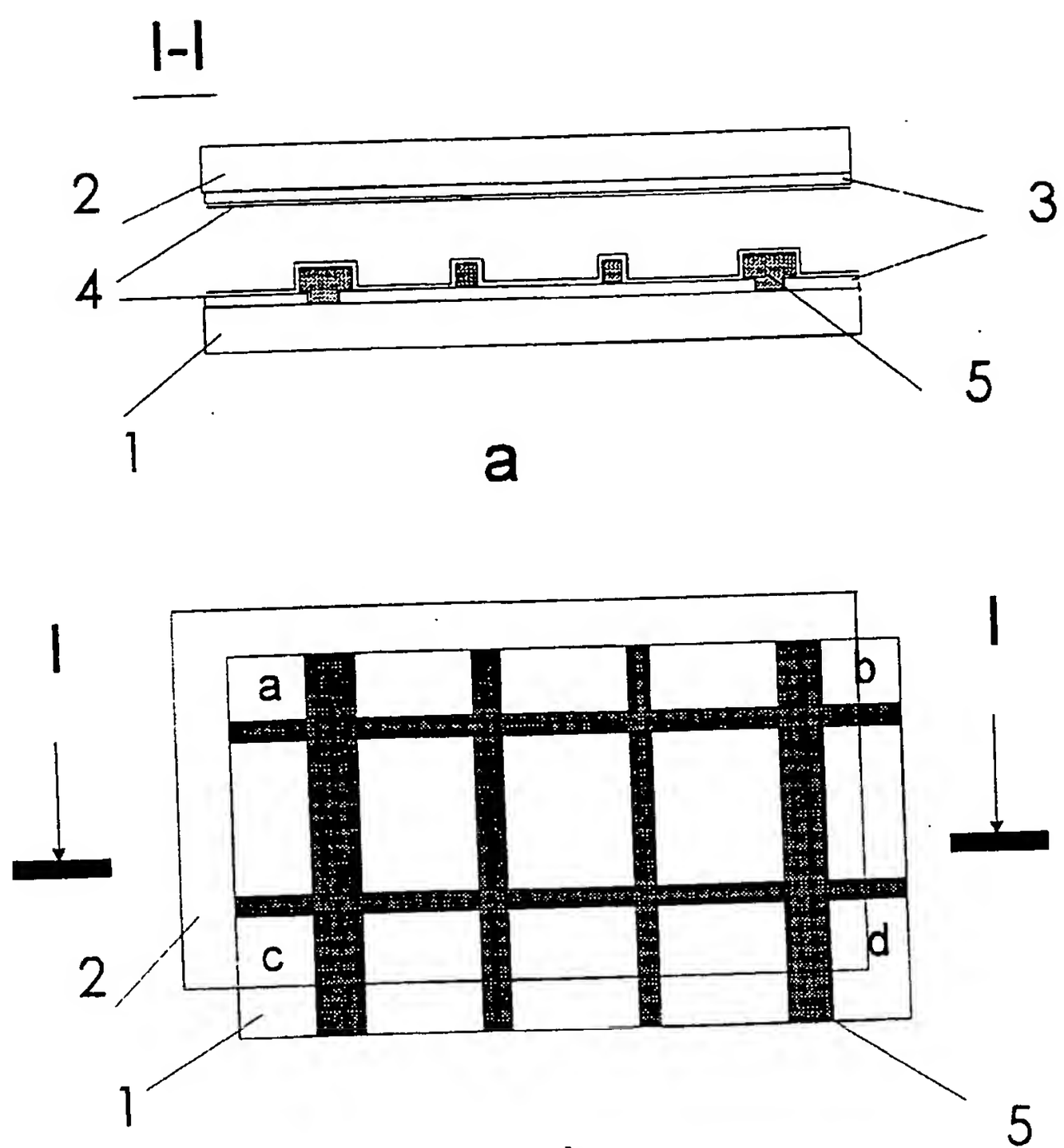


Fig. 1

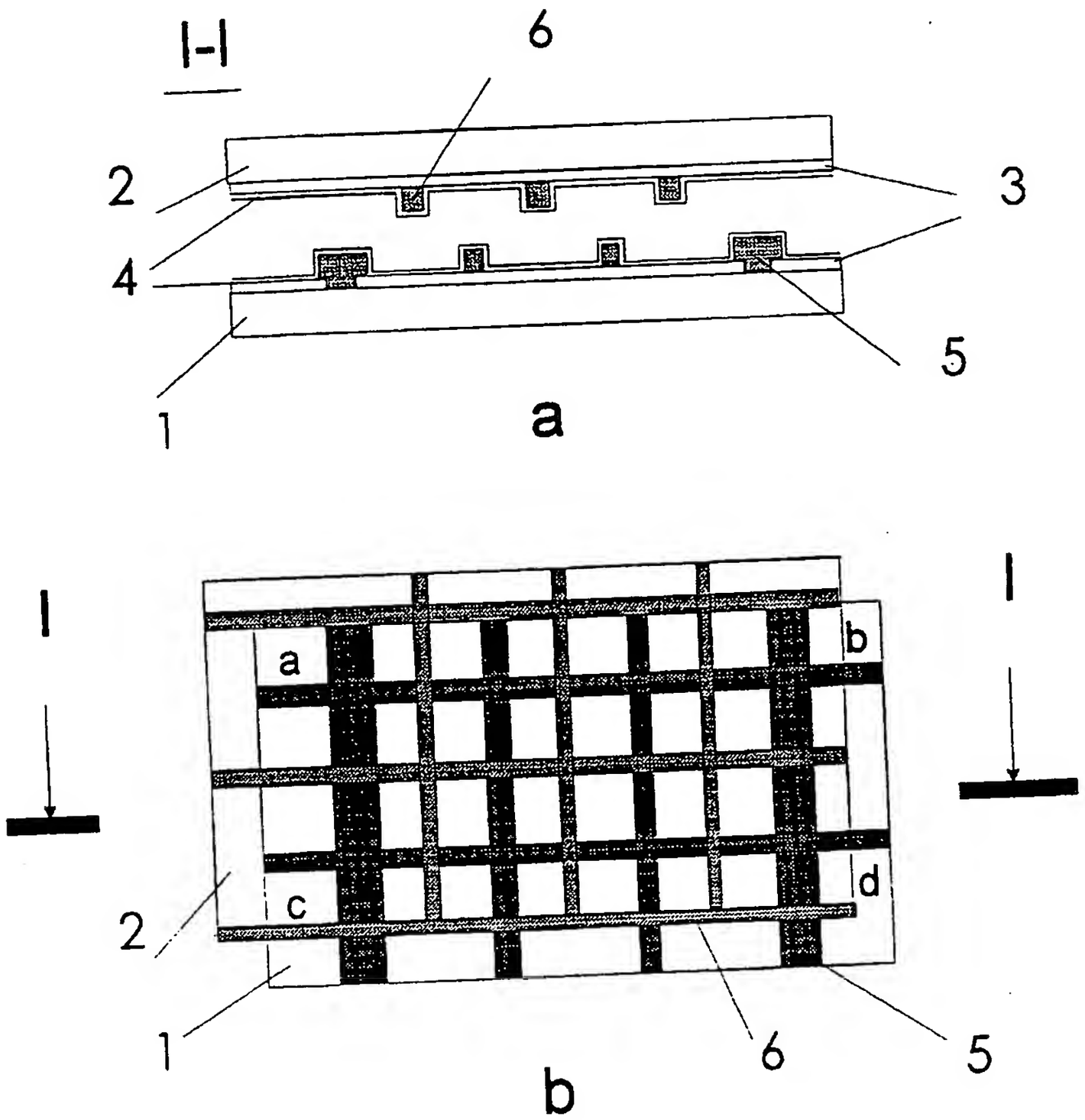


Fig.2

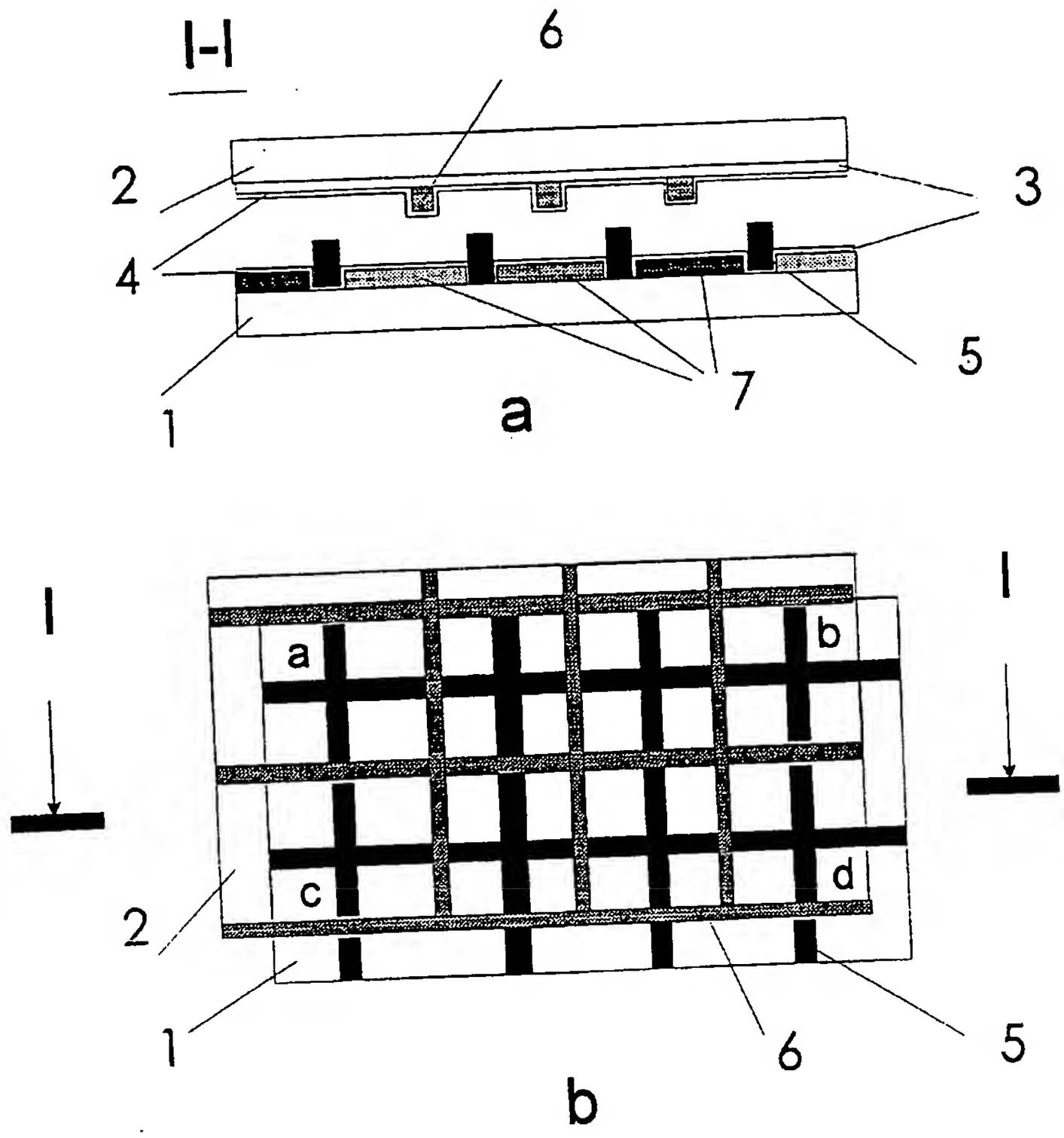
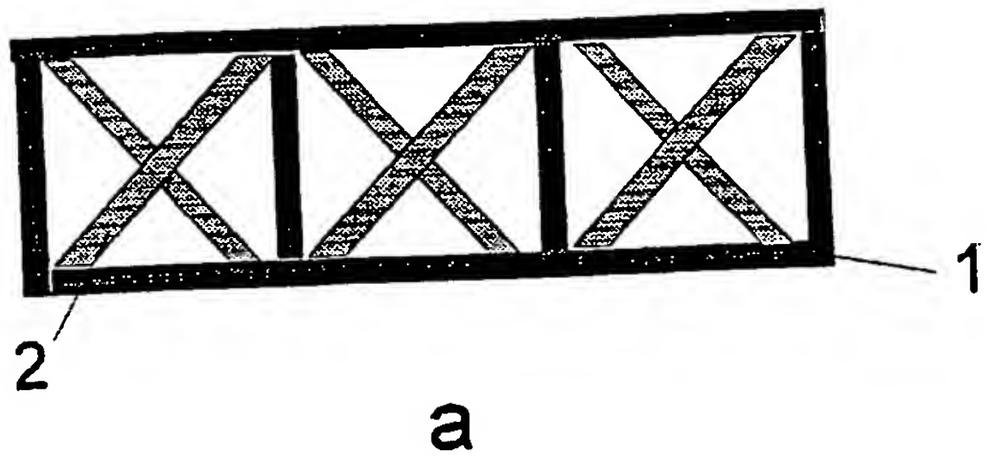
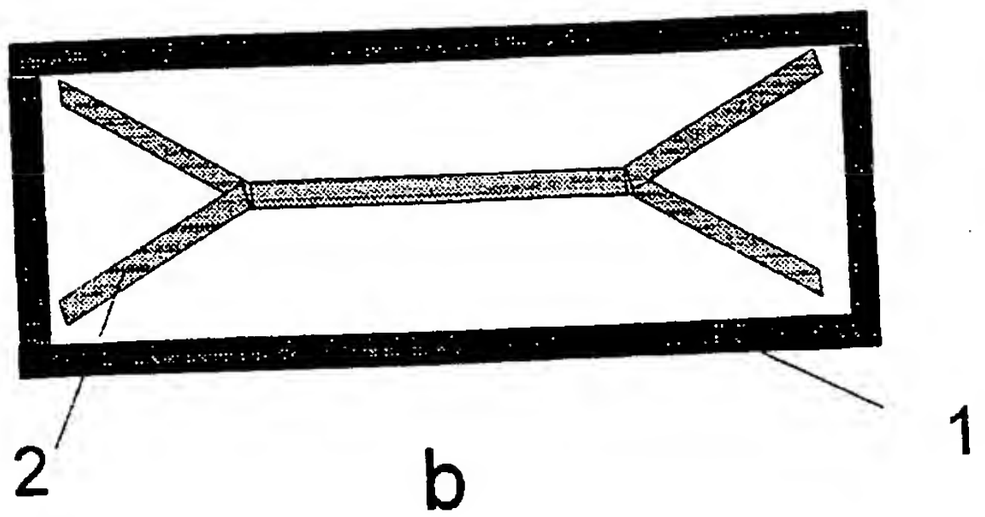


Fig. 3



a



b

Fig. 4

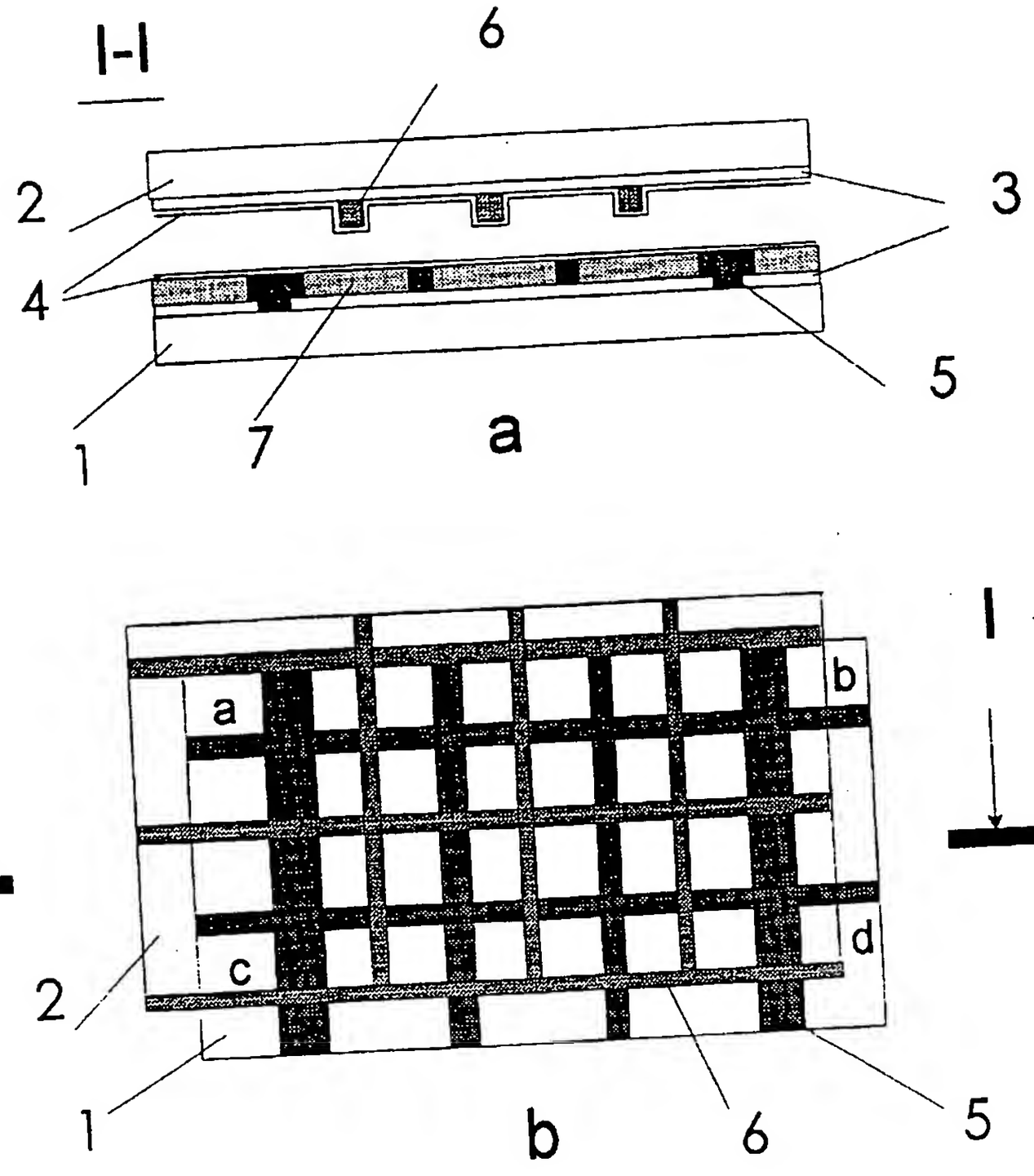


Fig. 5

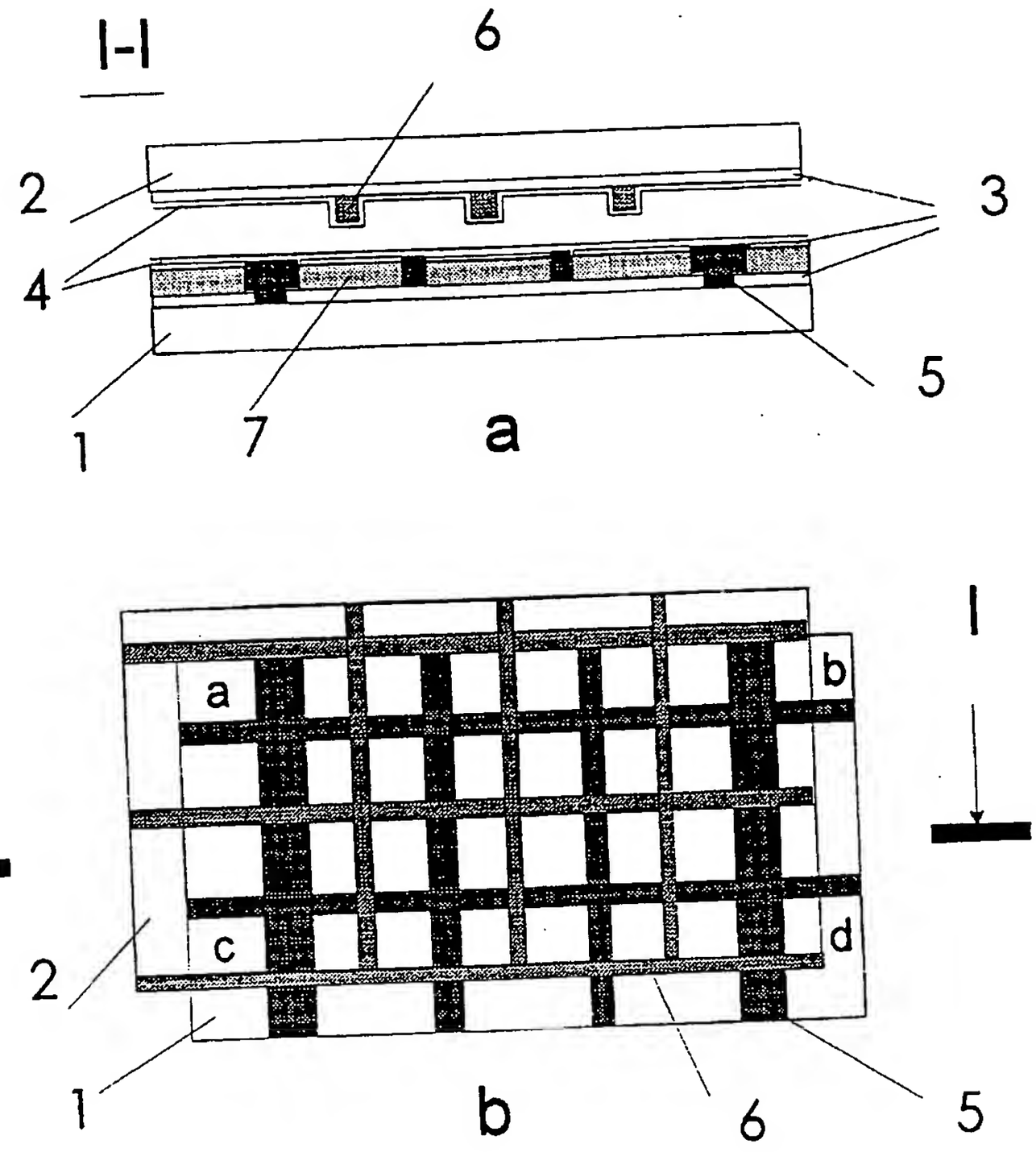


Fig. 6

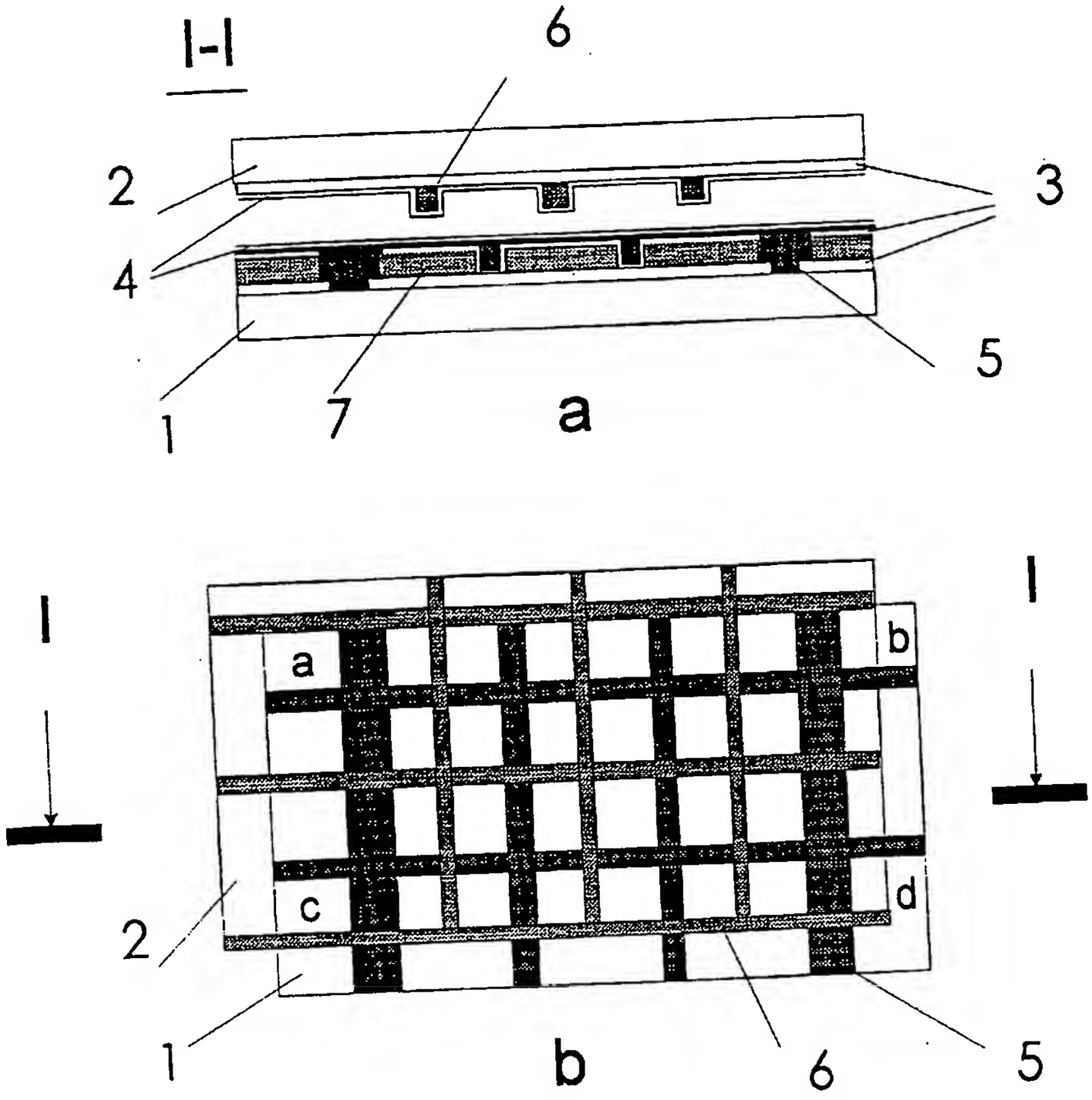


Fig. 7

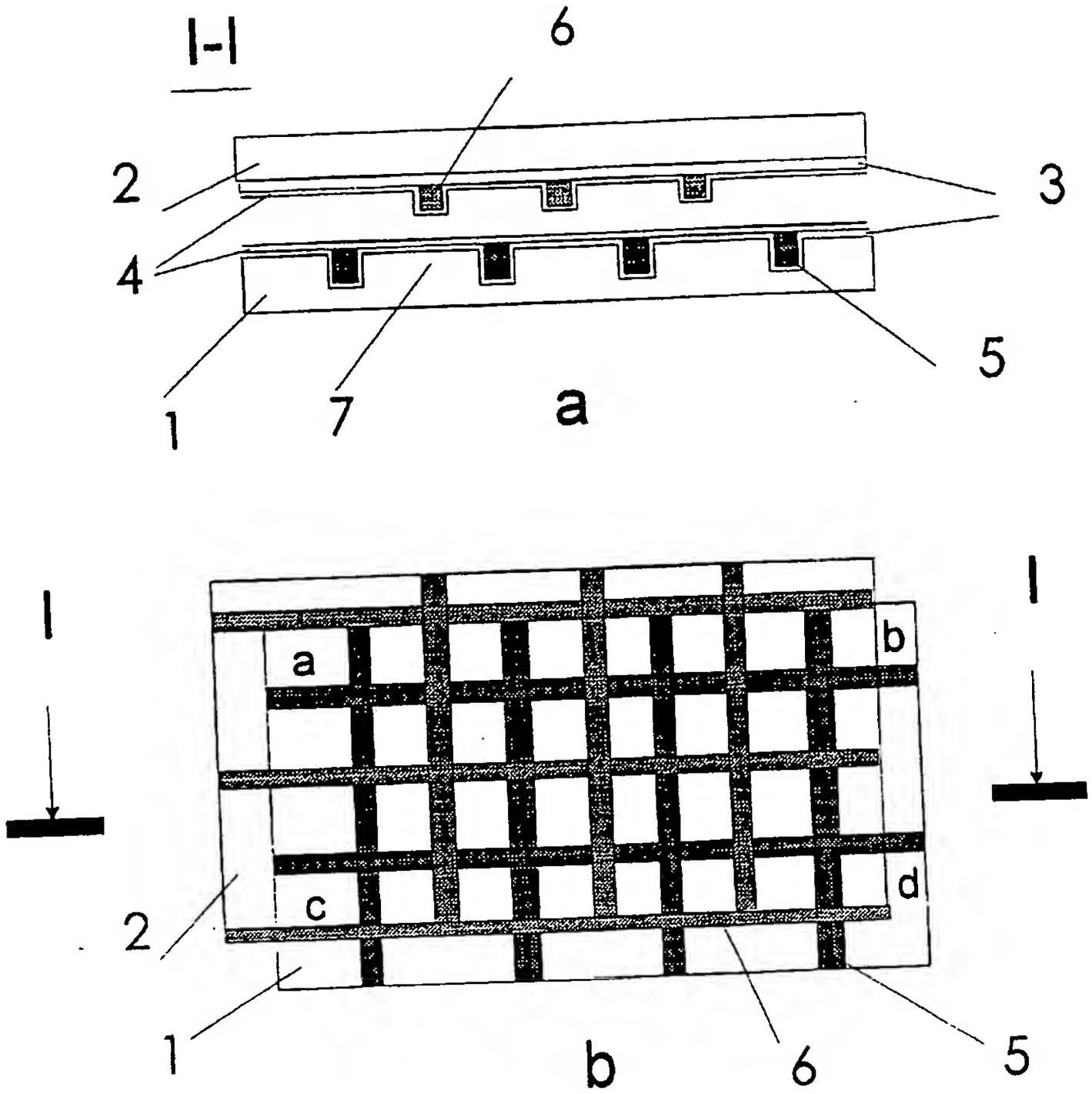


Fig. 8

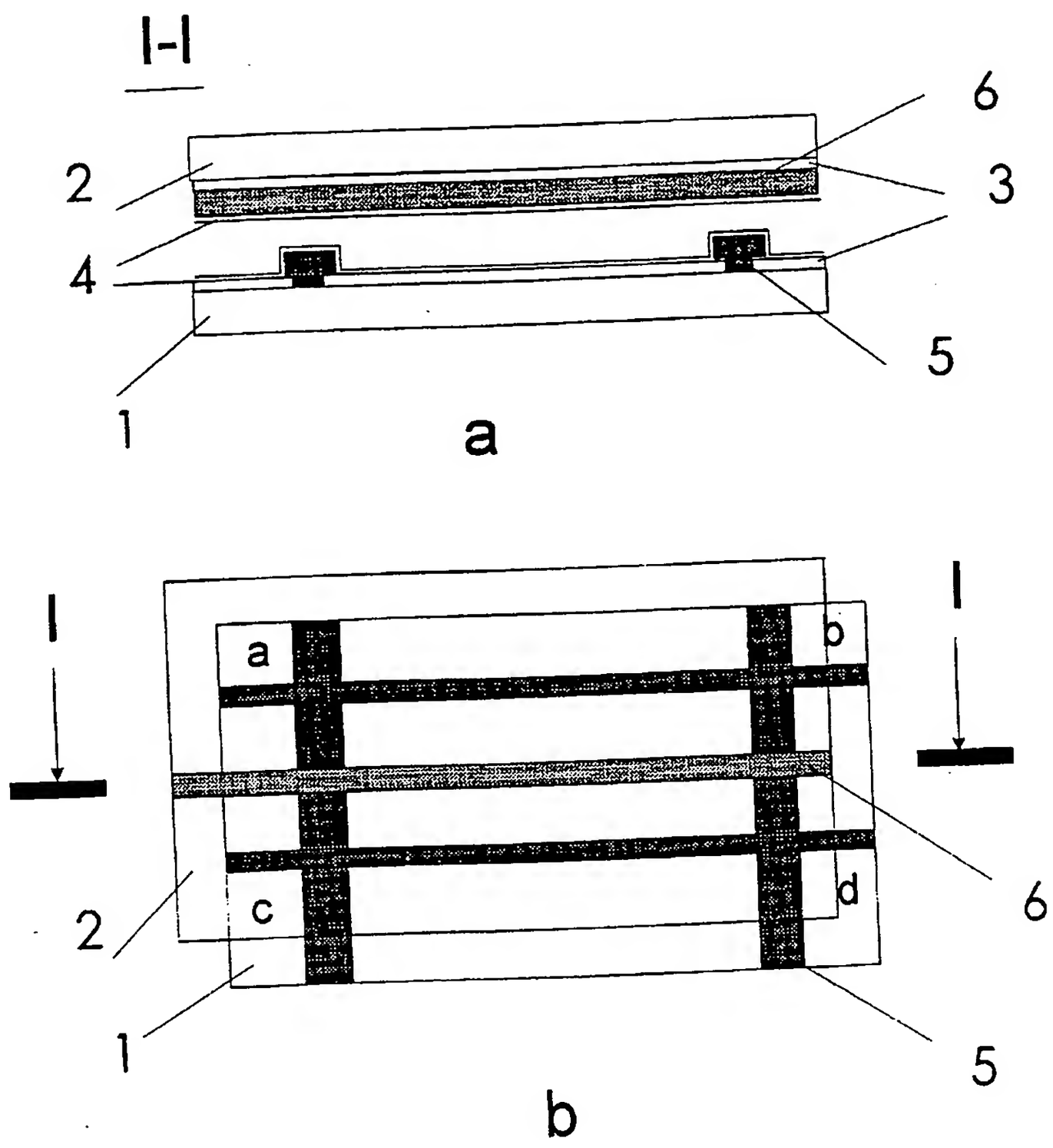


Fig. 9

INTERNATIONAL SEARCH REPORT

Inte ional Application No
PCT/BY 98/00008

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G02F1/1337 G02F1/1333

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KONOVALOV: "Multi- Domain Vertically Aligned Mode" 1998 SID INTERNATIONAL SYMPOSIUM. DIGEST OF TECHNICAL PAPERS. ANAHEIM, CA, USA, 17-22 MAY 1998, vol. 29, page 44.2L XP002098703 1998, Santa Ana, CA USA, Soc. Inf. Display, USA see the whole document ---	1,21
X	EP 0 854 377 A (SHARP KK) 22 July 1998 see page 9, line 11 - page 11, line 14; figure 5A --- -/--	1-3,9, 21-23

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 April 1999	22/04/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Diot, P

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Int. onal Application No
PCT/BY 98/00008

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	LIEN: "Ridge and Fringe- Field Multi-Domain Homeotropic LCD." 1998 SID INTERNATIONAL SYMPOSIUM. DIGEST OF TECHNICAL PAPERS. ANAHEIM, CA, USA, 17-22 MAY 1998, vol. 29, pages 1123-1126, XP002098704 1998, Santa Ana, CA, USA, Soc. Inf. Display, USA cited in the application see the whole document	1,21
E	EP 0 884 626 A (FUJITSU) 16 December 1998 see page 25, line 07 - line 45 see page 43, line 13 - page 47, line 31; figure 174	1-6,9,21
X	US 5 644 415 A (AOKI HISASHI ET AL) 1 July 1997 see column 3, line 33 - line 66 see column 6, line 56 - column 7, line 30	1-3
A	see column 14, line 04 - line 53	9
A	TAKEDA: "A Super- HIgh Image Quality Multi-Domain Vertical Alignment LCD by New Rubbing-Less Technology " 1998 SID INTERNATIONAL SYMPOSIUM. DIGEST OF TECHNICAL PAPERS. ANAHEIM, CA, USA, 17-22 MAY 1991, vol. 29, pages 1070-1080, XP000791252 1998, Santa Ana , CA, USA, Soc. Inf. Display, USA cited in the application see the whole document	1-3,5, 21-23
X	ANONYMOUS: "Liquid Crystal Display" IBM TECHNICAL DISCLOSURE BULLETIN, vol. 41, no. 409138, May 1998, page 647 XP002099562 New York, US see the whole document	1

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte. ...nal Application No
PCT/BY 98/00008

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0854377 A	22-07-1998	JP 10186330 A	14-07-1998
		JP 10186331 A	14-07-1998
		JP 11072793 A	16-03-1999
EP 884626 A	16-12-1998	NONE	
US 5644415 A	01-07-1997	JP 7175037 A	14-07-1995
		JP 7181499 A	21-07-1995